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SUNDASALANGIDAE, A NEW FAMILY OF MINUTE FRESHWATER SALMONIFORM FISHES FROM SOUTHEAST ASIA

By

Tyson R. Roberts

California Academy of Sciences, Golden Gate Park, San Francisco, CA 94118

ABSTRACT: **Sundasalangidae, a new family of minute freshwater salmoniform fishes related to the Salangidae or East Asian icefishes, is based upon a new genus and two new species recently discovered in Southeast Asia, *Sundasalanx praecox* and *S. microps*, both described in the present paper. With males and females sexually ripe at standard lengths of only 14.9 mm, *S. praecox* is the smallest known adult salmoniform and is among the smallest of all adult vertebrates. The new family differs from all other teleosts including Salangidae in the following features of its skeletal anatomy, which is largely cartilaginous: the two halves of the pectoral girdle are united to each other by a median scapulocoracoid cartilage; in branchial arches 1–3 the basibranchials and hypobranchials of either side are represented by a single cartilaginous element; and each half of the pelvic girdle is provided with a pair of rod-shaped parapelvic cartilages. Despite these and many other differences, Sundasalangidae and Salangidae are clearly closely related. They agree with each other but differ from all other known teleosts in having the jaw suspension with bilaterally paired palatohyomandibuloquadrate cartilages.**

Introduction

Among the freshwater fishes recently collected by the author in Southeast Asia are two samples, one from far up the mainstream of the Kapuas River in Kalimantan (Indonesian Borneo) and the other from a creek draining into the Tale Sap in peninsular Thailand, of minute transparent teleosts with a skeleton that is almost entirely cartilaginous (Figs. 1–2). Superficially resembling drawings of early or mid-metamorphic leptocephalus larvae of *Elops* (cf. Gehringer 1959:figs. 10–11), closer study of the fishes in these samples reveals that they are sexually mature, represent two very distinct species, and are actually salmoniforms most closely related to the East Asian icefishes of the family Salangidae. Yet they differ so markedly from Salangidae, and in certain respects from all other known teleosts, that a new family is proposed for them.

Methods and Materials; Acknowledgments

Observations on the largely cartilaginous skeletal anatomy of Salangidae and Sundasalangidae have been made on specimens prepared by means of the newly developed alcian blue–alizarin technique for counterstaining cartilage and bone in whole, cleared specimens of small vertebrates (Dingerkus and Uhler 1977). I am grateful to Robert Drewes of the California Academy of Sciences for preparing specimens of both species of Sundasalangidae and of all of the genera and nearly half of the species of Salangidae, and also to William N. Eschmeyer, Curator of Fishes of the California Academy of Sciences, for making the specimens of Salangidae available. A complete list of these skeletal preparations will be presented in an extensively illustrated account of the skeletal anatomy of Salangidae and Sundasalangidae now

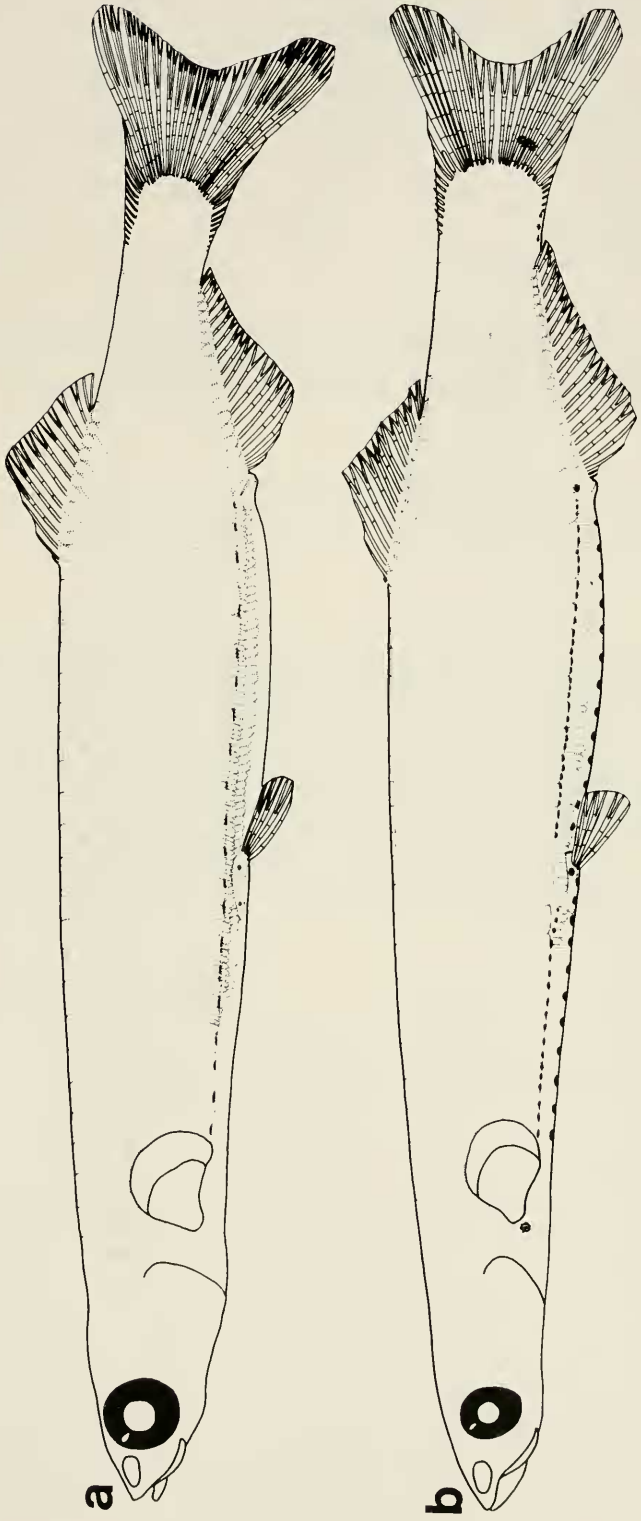

FIGURE 1. (*a*) *Sundasalanx praecox*, based mainly on 17.0-mm paratype, MCZ 54390; (*b*) *Sundasalanx microps*, based mainly on 17.0-mm paratype, CAS 44220.

being prepared (Roberts, ms). I also thank Karsten E. Hartel and William Fink for loaning the specimens of *Sundasalanx praecox* which had been deposited by me in the Museum of Comparative Zoology at Harvard. My fieldwork in Thailand and Indonesia which led to the discovery of *Sundasalanx* was supported or aided by the following institutions: Museum of Comparative Zoology; Kasetsart University College of Fisheries; National Research Council, Thailand; Indonesian National Research Council (LIPI); and Smithsonian Tropical Research Institute (STRI). I particularly thank Supap Monkolprasit of Kasetsart and Ira Rubinoff of STRI for facilitating my travel and fieldwork. The preparation of this paper was supported by grant DEB77-24574 in the Systematic Biology Program of the National Science Foundation.

Sundasalangidae, new family

Type-genus: *Sundasalanx*, new genus.

Sundasalangids differ from all other teleosts, so far as known, in having a pectoral girdle with a median cartilaginous scapulocoracoid and a single pair (one on each side) of fan-shaped, "externalized" radial cartilages (Fig. 3) which form the peduncular portion of the pedunculated pectoral fins; a pair of rod-shaped parapelvic cartilages (Fig. 2) which apparently serve to anchor each half of the pelvic girdle to the free ventral end of a myotomal muscle; and branchial arches with hypobranchial elements 1–3 absent as separate elements, evidently fused to basibranchials 1–3 (Fig. 4). In Salangidae the scapulocoracoids are paired, separate elements, and the two halves of the pectoral girdle are separate from each other; each pectoral fin is supported by three or more radial cartilages; parapelvic cartilages are absent; and the first three branchial arches have separate basibranchial and hypobranchial elements.

Members of the Sundasalangidae agree with most Salangidae but apparently differ from all other teleosts in having a jaw suspension consisting of a single cartilaginous element or palatohyomandibuloquadrate (Fig. 5); they agree with Salangidae but apparently differ from adults of all other known teleosts (Nelson 1960:61) in having well-developed separate fourth hypobranchials (Fig. 4). Sundasalangids agree with the Salangidae but differ from adults of most other teleosts in having pedunculate pectoral fins; a scaleless body; no symplectics; no circumorbital bones; myotomal muscles failing to meet at ventral midline of body; and maxillary bones with distal two-thirds curved inwards underneath the head so that the portion of the maxillary toothrow they bear projects medially rather than ventrally when the mouth is closed. In addition to the unique characters associated with their pectoral and pelvic girdles and gill arches, which have been described above, Sundasalangidae differ from Salangidae in their much smaller size (the smallest salangids are over 35 mm in standard length [SL] when sexually mature); olfactory organs each with a single nasal opening instead of two openings; interopercle absent; pectoral fin without segmented bony rays; adipose fin absent; sexually mature males without enlarged or otherwise modifed anal fin, or a row of large pored scales on the base of the anal fin (present in all salangids); pelvic fins five-rayed (seven-rayed in all salangids); myotomes <-shaped (ȝ-shaped in salangids); and vertebrae only 37–43 (48–77 in Salangidae). Sundasalangidae comprises two species, *Sundasalanx praecox* and *S. microps*, described below.

Sundasalanx, new genus

Type-species: *Sundasalanx praecox*, new species.

Minute, transparent, freshwater fishes with a largely cartilaginous skeleton; a single large nasal opening on each side of snout; body bilaterally compressed, scaleless; branchiostegal rays four (usually three in Salangidae); pectoral fins pedunculate, without bony rays; pelvic fins midabdominal, with five rays; myotomal musculature of opposite sides widely separated ventrally; each half of pelvic girdle anchored to free ventral end of a myotomal muscle by a pair of parapelvic cartilages; a median membranous keel extending on abdomen from pelvic fins to vent; gut a simple straight tube with no differentiated stomach; vent immediately anterior to anal fin origin; no secondary sexual dimorphism or dichromatism; vertebrae (including hypural centrum as one) 37–43.

Dentition (Figs. 4–5): Premaxillary and maxillary with a single row of minute conical teeth; lower jaw with two rows of minute conical teeth, inner row curved inwards away from outer row; fifth ceratobranchials with 0–10 conical teeth. Roof of mouth and upper pharyngeal elements edentulous.

Median fins: Dorsal and anal fins originating

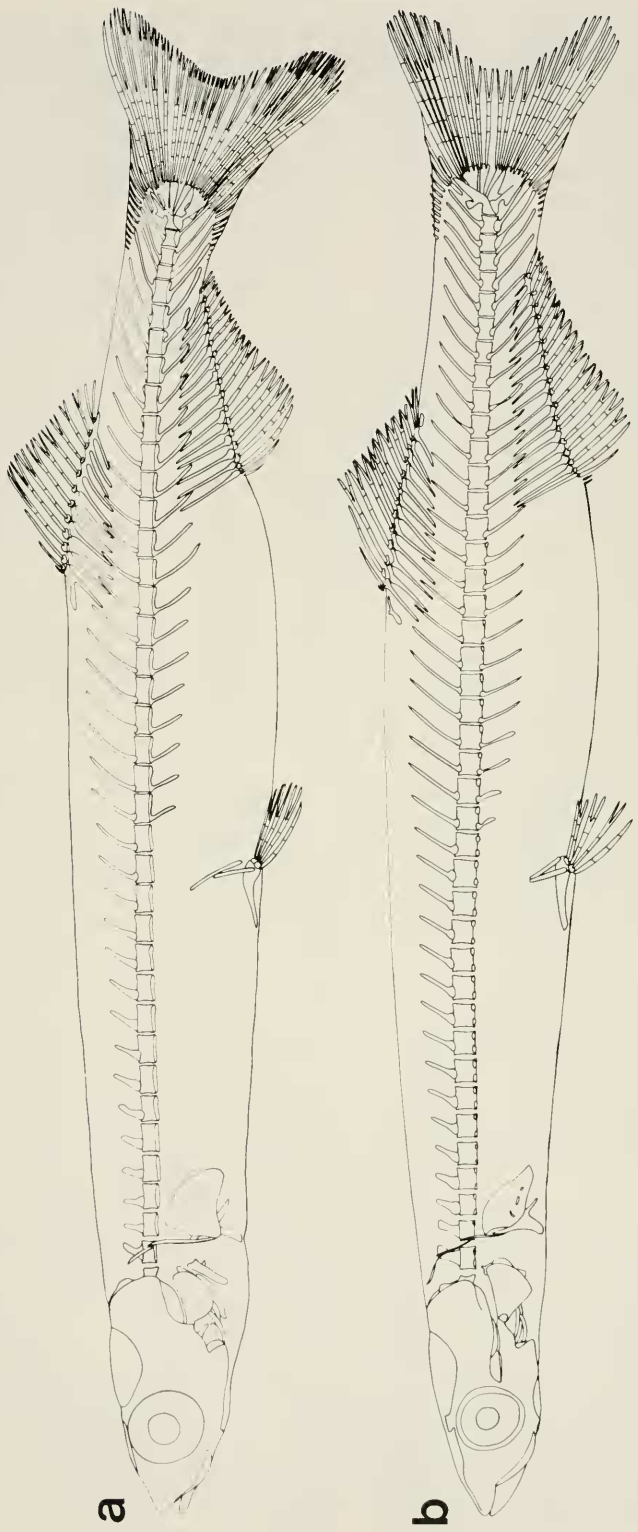

FIGURE 2. (*a*) *Sundasalanx praecox*, MCZ 54390, 17.0 mm; (*b*) *Sundasalanx microps*, CAS 44220, 17.0 mm.

on posterior third of body; origin of anal fin on a vertical through or slightly posterior to middle of dorsal fin base. Dorsal fin with three simple and 8–11 branched rays (last ray, counted as one, split to base); anal fin with 3–4 simple rays and 12–17 branched rays (last ray split to base). Adipose fin absent. Caudal fin moderately forked, with 10 + 9 principal rays and 9–12 + 7–11 procurrent rays.

ETYMOLOGY.—Sunda (=Sundaland, the continental landmass of Southeast Asia connected to the Asian mainland by the isthmus of Kra) plus *Salanx* (Greek, masc.), type-genus of the family Salangidae.

Sundasalanx praecox, new species

(Figures 1a, 2a, 4a, 5a, 6a)

MATERIAL.—**Holotype:** MCZ 47129, 17.2-mm male with well-developed testes, from Khlong Falamee, a swift, muddy creek 1–2 m deep and 3–5 m wide with hard-packed mud bottom flowing into inner lake of Tale Sap, at about 2 km W of Pak Payoon on the isthmus of Kra, southern Thailand; nylon flyscreen pushnet; 20 June 1970.

Paratypes: MCZ 54390, 119: 14.9–18.3 mm, same collection data as holotype; nine utilized for alcian blue–alizarin preparations.

DIAGNOSIS.—*S. praecox* is distinguished from *S. microps*, its only congener, by its much larger eyes: horizontal diameter of eye measured in 10 specimens including smallest and largest specimen of each species, 4.3–5.0% of SL in *S. praecox* vs. 2.7–3.2% in *S. microps*. In *S. praecox* eyeballs separated from each other by a distance about equal to transverse diameter of their pigmented portion, while in *S. microps* distance separating them equal to at least twice transverse diameter. In *S. praecox* head deeper, more compressed, and nasal septum much narrower (Figs. 1, 6). Maxillary teeth about 15–19 vs. about 30 (Fig. 5). Palatohyomandibuloquadrate cartilage entire vs. palatine separate from hyomandibuloquadrate (Fig. 5). Fifth ceratobranchial with about 8–10 large conical teeth vs. 0–3 small conical teeth (Fig. 4). First gill arch with 1 + 9 well-developed gill rakers vs. 0 + 1–2 rudimentary gill rakers; all ceratobranchials with well-developed gill rakers vs. gill rakers greatly reduced in size, and ceratobranchials moderately elongate vs. slender and very elongate (Fig. 4). Posterior parapelvic cartilage originating dorsal to anterior parapelvic cartilage and extending further into myotomal muscle mass instead of lying parallel with anterior parapelvic cartilage (Fig. 2). No midventral row of large, round pigment spots on abdomen and postpelvic abdominal keel corresponding in number to myotomal muscles (present in *S. microps*) (Fig. 1). Anal fin with 12–15 branched rays vs. 14–17. Caudal peduncle more slender (Figs. 1, 2). Vertebral centra more elongate (Fig. 2.) Total vertebrae (excluding basioccipital half centrum but counting upturned hypural centrum as one) 37(n = 2) or 38(7) vs. 41(2), 42(4) or 43(1).

Sex: The 120 *S. praecox* from Khlong Falamee were all caught in a segment of the creek less than 100 m long and presumably represent a random sample from a single breeding population. The sample includes 32 males 14.9–18.3 mm SL with well-developed testes, 19 females 14.9–17.3 mm with well-developed eggs, and 68 specimens 15.2–17.9 mm of undetermined sex in which the gonads are inactive or relatively undeveloped. The testes extend nearly the entire length of the abdomen dorsolaterally to the gut. Obscured anteriorly by the liver, the testes are otherwise readily visible through the transparent ventral body wall and translucent ventral portion of the myotomal muscles (Fig. 1a); they are uniformly divided throughout their length into obliquely aligned divisions or partitions, of which there are about five or six per myotome. Similarly partitioned testes, present in some minute or small freshwater African Clupeidae (personal observation with Peter Whitehead) have not been observed in Salangidae. The largest specimen in the entire sample is a male of 18.3 mm with very well developed testes; the smallest male, 14.9 mm, has testes almost as well developed. In females the ovaries also extend virtually the entire length of the abdomen and lie dorsolateral to the gut. Eggs in varying stages of development are present. In the ripest ovaries observed, the largest eggs, 0.20–0.25 mm in diameter, are aligned in a single row of about 25 eggs in each ovary. The smallest female, 14.9 mm, has ovaries with well-developed eggs.

Food: Gut contents, either whole macroscopic animals or fragments of them, readily observed through the transparent body and gut walls, are present in 34 (28%) of the 120 specimens. In the other 86 (72%), the guts appear to be entirely empty. Items ingested consist exclusively of animals, almost all apparently either aquatic insect larvae or segmented vermiform organisms (also aquatic insects?). None of the

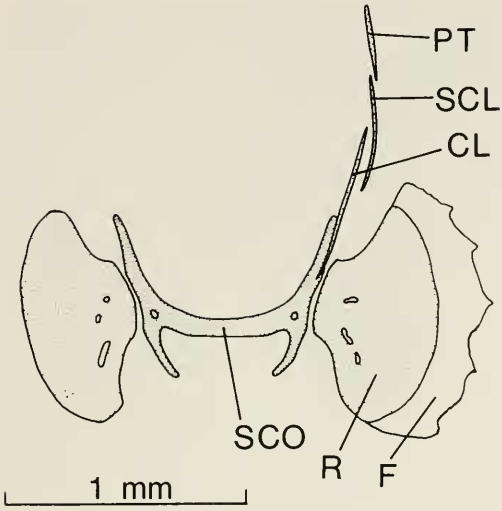

FIGURE 3. *Sundasalanx microps*, CAS 44220, 17.0 mm, pectoral girdle and fin (ventral view). PT, SCL, CL = posttemporal, supracleithrum, cleithrum; R, F = pectoral radial, frayed margin of fin; SCO = scapulocoracoid (secondary pectoral girdle and frayed margin of fin of right side omitted).

guts contain plant material, sediment, or significant amounts of nonidentifiable debris.

ETYMOLOGY.—Latin *praecox*, too early ripe, premature.

Sundasalanx microps, new species

(Figures 1b, 2b, 3, 4b, 5b, 6b)

MATERIAL.—**Holotype:** Museum of Zoology, Bogor, Indonesia, 3000, 17.0 mm, near shore of mainstream Kapuas River at Kampong Nibung, about 100 km NE of Sintang and 7 km NE of Selimbau, Kalimantan, Indonesia, lat. 0°39′N, long. 112°10.5′E; current moderate, water muddy, 26°C, pH 5.5–6, bottom soft mud, depth to 1 m; nylon flyscreen seine; 5–6 July 1976.

Paratypes: Museum of Zoology, Bogor, Indonesia, 3001, and CAS 44220, 34:14.6–19.9 mm, same collection data as holotype, seven utilized for alcian blue–alizarin preparations.

DIAGNOSIS.—*S. microps* is distinguished from *S. praecox*, its only known congener, in the diagnosis of that species given above.

Sex and food: The gonads in the sample of 35 *S. microps* are not well developed, and I have been unable to distinguish males and females. The guts of nearly all appear to be empty; a few contain unidentified fragments, but no whole insect larvae or other animals, plant material, or sediment.

ETYMOLOGY.—Greek *mikros*, small, little, and *ops*, eye.

Sundasalanx species undetermined

Vaillant (1893:110–112, pl. 2, fig. 4) described some delicate little fishes collected in the Ka-

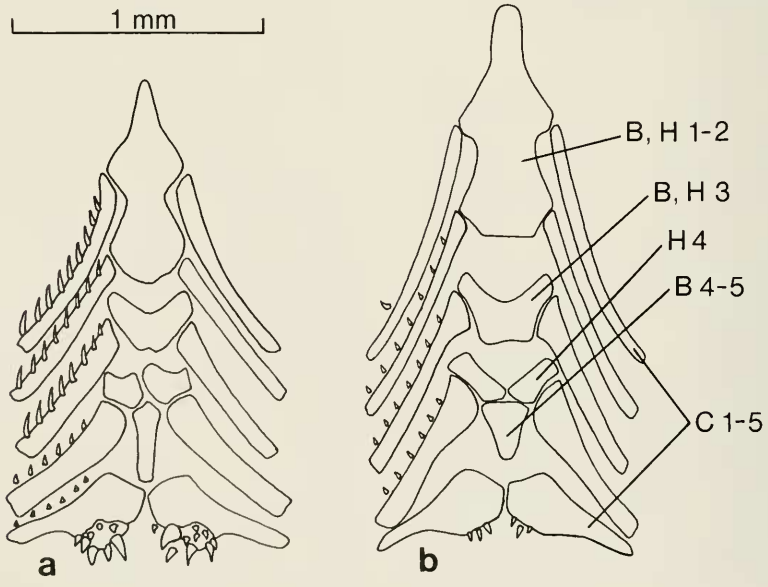

FIGURE 4. Ventral parts of gill arches, dorsal view (gill rakers of right side omitted): (*a*) *Sundasalanx praecox*, MCZ 54390, 17.2 mm; (*b*) *Sundasalanx microps*, CAS 44220, 17.2 mm. B, H, C = basibranchial, hypobranchial, ceratobranchial (see text for explanation).

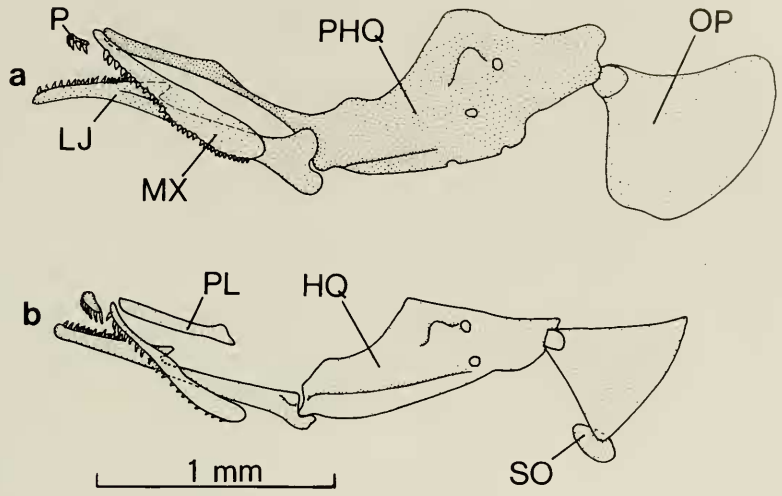

FIGURE 5. Jaws, jaw suspension, and gill cover, lateral view: (*a*) *Sundasalanx praecox*, MCZ 54390, 17.1 mm; (*b*) *Sundasalanx microps*, MCZ 44220, 17.0 mm. P, MX, LJ = premaxillary, maxillary, lower jaw; PHQ = palatohyomandibuloquadrate; PL, HQ = palatine, hyomandibuloquadrate; OP, SO = opercle, subopercle.

puas River by Chaper in 1890–91 which he hesitantly identified as young needlefish (?*Belone caudimaculata*). Subsequent to completing the manuscript of this paper, I visited the Muséum National d'Histoire Naturelle in Paris, where Chaper's Kapuas collection is deposited, and examined this material. The specimens (MNHN 91-596, 27:18.8–23.4 mm), although not in the best state of preservation, are clearly *Sundasalanx* but do not agree well with my diagnoses of either *S. microps* or *S. praecox*. They agree with *S. microps* rather than *S. praecox* in their relatively large size, vertebral counts of about 42–45, modally 43 (determined by counting the myotomes), and number of branched anal fin rays, about 15–18. On the other hand, the eyes seem to be much larger than in *S. microps* and possibly even larger than in *S. praecox*, and the number of maxillary teeth fewer than in *S. microps* and *S. praecox*. In nearly all of the specimens, the eyes are ruptured or their shape so distorted that horizontal diameter cannot be measured accurately. In a 22.5-mm specimen in which the eye is intact and nearly normal in shape, its horizontal diameter is 5.0% of SL (2.7–3.2% in *S. microps*, 4.3–5.0% in *S. praecox*). The eyeballs are so large that they nearly meet in the middle of the head, whereas in both *S. microps* and *S. praecox* they are considerably further apart. The number of teeth on the maxillary bone is only 10–14 (n = 3) vs. about 30 in *S. microps* and about 15–19 in *S. praecox*. A row of melanophores is visible on the side of the body external to the free ventral ends of the myotomal muscles, but not on the ventral midline of the abdomen and postpelvic abdominal keel (the latter present in *S. microps* but not in *S. praecox*). I was unable to detect testes or eggs in any of the specimens, although many of

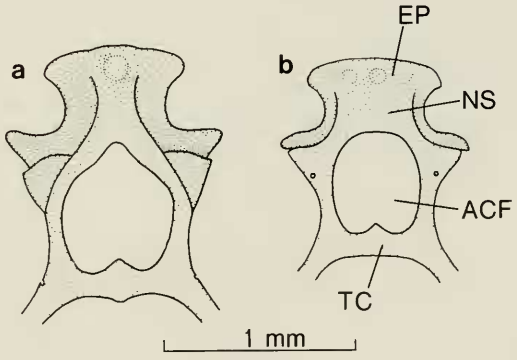

FIGURE 6. Anterior end of cranium, dorsal view: (*a*) *Sundasalanx praecox*, MCZ 54390, 17.2 mm; (*b*) *Sundasalanx microps*, CAS 44220, 17.0 mm. EP, NS = ethmoid plate, nasal septum; ACF, TC = anterior cranial fontanel, tectum cranii.

them have ruptured abdomens. The precise locality where they were collected is unknown, but judging from Vaillant's remarks (1893:60) they must have been taken in or near the mainstream of the Kapuas River somewhere between its confluence with the Sebruang River and Semitau, or in the same general area as *S. microps*, the type-locality of which is less than 40 km upriver from Semitau. So far as I have been able to find out, no additional material of *Sundasalanx* has been reported upon or collected by anyone else.

DISCUSSION

Alizarin is a specific stain for bone but does not always stain bone in an early stage of development or poorly calcified bone. Alcian blue usually stains cartilage, but apparently also sometimes stains uncalcified bone or bone in an early stage of development. In some instances structures which are clearly bone or cartilage fail to be noticeably stained by either alizarin or alcian blue. Thus, it is not possible to state in every instance which skeletal elements in Sundasalangidae and Salangidae are cartilage and which are bone based merely on their staining reaction to alcian blue and alizarin. In Sundasalangidae the only skeletal elements deeply stained with alizarin are vertebral centra, distal ends of neural and haemal spines, caudal fin rays, hypural fan, teeth, and bony toothplates on fifth ceratobranchials. Maxillary bone, tooth-bearing portion of the lower jaw, secondary pectoral fin girdle (posttemporal, supracleithrum and cleithrum) and pelvic fin rays are weakly stained with alizarin. Gill rakers, branchiostegal rays, and subopercle are either weakly stained with alcian blue or are not stained at all, in which case they may be difficult to observe even with transmitted light. In alcian blue–alizarin preparations of adult Salangidae, the distribution of elements stained by alcian blue and alizarin is basically similar to that in Sundasalangidae, but alizarin is taken up more extensively.

Sundasalanx praecox is among the smallest of adult vertebrates and is the smallest known salmoniform fish. *Sundasalanx microps* is the smallest of more than 250 fish species present in the Kapuas River (personal observations), thus providing an excellent example of survival of a peripheral-division fish family in the midst of a rich primary-division freshwater ichthyofauna by evolution of minute body size and a wholly freshwater life history (for further discussion see Roberts 1978:20–21). Salangidae are anadromous and freshwater fishes inhabiting coastal waters and rivers of East Asia from North Vietnam northwards to Korea, Vladivostok, and Sakhalin. They are unknown from Thailand and Borneo. The basic references to systematics and geographical distribution of Salangidae are Fang (1934) and Wakiya and Takahasi (1937).

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Golden Gate Park
San Francisco, California 94118